

# OBSERVATIONS ON THE LITTLE BROWN BAT *EPTESICUS PUMILUS* GRAY IN TASMANIA

by

R. H. GREEN

QUEEN VICTORIA MUSEUM  
LAUNCESTON, TASMANIA

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## ABSTRACT

The results of three years' (1962-1965) observations on the Little Brown Bat, *Eptesicus pumilus* in northern Tasmania, are recorded.

The diurnal roosts of five maternal colonies are described and observations on their exit and entry flights are given.

The three main methods used to capture specimens are described and 206 *E. pumilus* were collected by these methods. Of this total 83 were examined and processed into the collections of the Queen Victoria Museum. The remaining 123 were banded and released and of these 86 were subsequently recaptured 216 times on 34 trap nights.

The longest distance recovery was three miles and the longest time lapse was nineteen months.

Colonies will use more than one diurnal roost at the same time and interchanging by individuals between these roosts is usual.

Colonies are at their greatest numerical strength in January but autumn dispersal greatly reduces the colony during the winter months. A build-up occurs in the spring and parturition takes place between the end of November and mid December with a single birth being normal. Post-partum copulation and seminal storage is indicated by the structure of colonies and seasonal behaviour of males.

The growth, pelage, tooth eruption and behaviour of young are described and progressive mensurations tabulated.

Pelage variants are not indicative of sex but appear to be influenced by age and possibly local environment.

Tooth wear is apparently associated with age and in some cases has been found to be extremely severe. Body weight generally increases throughout the first year of the bat's life and from six months of age the weight of females usually exceeds that of males.

Observations are recorded on feeding, drinking, flight, swimming, voice, excreting and toilet.

## I. INTRODUCTION

This paper is based on data collected from various sources as opportunity permitted over a period of three years. The study was commenced in February 1962 with the banding of a colony at Green's Beach. These were the first bats of any species to be banded in Tasmania.

Four more colonies were located and subsequently the occupants of two were banded and released and most of the occupants of the other two were collected and processed into the collections of the Queen Victoria Museum. Odd individuals came to hand over the same period.

Retrapping was carried out at the three banding sites on a total of thirty-four evenings, observations were recorded and some individuals retained during the breeding season for cage study and dissection. This interference, particularly during the breeding season, was apparently the reason for desertion of the roosts by each of the banded colonies. Consequently it has not been possible to make repeated observations on any one colony for two successive years and much of the

data acquired has in itself created additional questions.

Much more work still remains to be done before the life cycle of *E. pumilus* is completely known but its small size, hidden roosts and shy habits makes the study on free living colonies most difficult. The results of the past three years' observations therefore are little more than an introduction and are here recorded for the use of future workers.

To avoid confusion, certain terms used in the text are defined here as follows:

Juvenile: Dependent young, from birth to about 60 days by which age the bat is flying and changing to an insectivorous diet.

Sub-Adult: Independent but sexually immature, covering the period from commencement of flight at about 60 days until the approach of the following breeding season at about nine months of age.

Adult: Having attained puberty, in excess of nine months of age.

Morphological differences between these categories are discussed later.

## II. DIURNAL ROOSTS

Although a number of reports have been received of bat colonies in buildings, trees and caves, most have proved valueless because the site was destroyed or abandoned by the bats before it could be visited and in every case the species was not positively identifiable from the description.

During the course of study, five major diurnal roosts have come under my notice. All were in wooden buildings and were subsequently found to house maternal colonies. They are briefly described as follows:

"Green's Beach" colony, at Green's Beach on the western side of the mouth of the Tamar River, reported 1: II: 1962, was found to be housed in two separate roosts about twenty-five feet apart. One roost (designated A) was in a three inch wall cavity of a shack, the bats gaining entry by way of small gaps between the window facias and the cement sheets covering the external walls. The other (designated B) was in the roof of a paling hut near the shack. The shingle roof had been covered with heavy tar paper and the colony was occupying the narrow space between the two materials. Bat faeces were found adhering to the outer wall in the vicinity of the entrances and the owners of the buildings complained of an offensive odour during the summer months. The painted surface of the inner wall of the shack was stained with urine and faeces were regularly falling through the shingles in the roof of the hut and fouling its contents.

Squeakings and rustling noises could be heard in the roosts at most times of the day, particularly in the roost on hot sunny days when the heat immediately beneath the tar paper must have been intense.

The shack owners told of a similar occupancy during the previous summer when quantities of bat faeces were found to have accumulated in crevices.

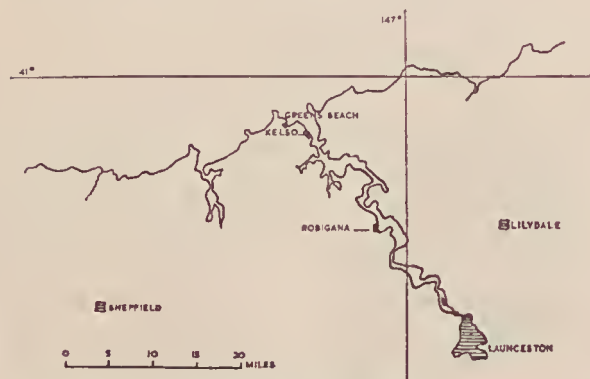


FIGURE 1. Sketch map based on the Tamar River showing the relative positions of the sites of the diurnal roosts mentioned in the text.

"Kelso" colony at Kelso, near the western side of the mouth of the Tamar River and about three miles south of Green's Beach colony was discovered following the finding of two juvenile *E. pumilus* on 8: II: 1964. The colony was located beneath the tar covered flat wooden roof of a substantial brick building. The bats were found to be living behind the facia boards and among the converging mass of wooden roof supports. Entry was gained by way of the corrugations on a lower roof which ran beneath the facia boards.

The bats could be clearly heard from the outside

and upon examination from the inside with the aid of a torch a number of bats were seen retreating from the light into the crevices between the roofing material.

The employees working in the building had no previous knowledge of the existence of the colony, though accumulated faeces indicated that it had probably been in use in a previous season.

"Lilydale" colony near Lilydale about ten miles north of Launceston, was discovered in the roof on an old shed when it was about to be demolished on 10: IV: 1964. Fourteen bats were collected by the owner and sent to the Queen Victoria Museum and were subsequently processed into the collections.

"Robigana" colony at Robigana on the west bank of the Tamar River was reported in October, 1964. It was occupying a small space where a verandah roof joined the weatherboards of an old wooden house. Entry was gained by way of the open verandah and the roost was reported to have been occupied during the previous summer.

The owners complained of fouling of the wall and floor by the faeces of the bats and had made several attempts to wash the colony out with a garden hose. Though bats had been dislodged by this means they could not be deterred from returning at a later date.

"Sheffield" colony, two miles south of Sheffield, was examined on 18: XI: 1964 and found to be occupying the space beneath a single corrugation of a sheet of roofing iron, where it capped a board on the end of a verandah roof in an old weatherboard house. Entry was gained from outside the verandah by way of the gaps between the sloping board and the weatherboards to which it was fixed. Bats could be heard inside the roost and it was reported to have been occupied the previous summer. A mist net set on the same evening captured twenty-four bats which were subsequently processed into the collections of the Queen Victoria Museum. Although some bats could still be heard in the roost at the cessation of netting activities, the roost was found to be deserted when the roofing iron was lifted on 5: XII: 1964.

A few solitary individuals have been collected at various times from roosts in sheds and timber stacks, or collected in flight at night.

Though bats have been reported flying in cave entrances no diurnal bat roosts have been discovered in Tasmanian caves.

## III. EXIT FROM AND RE-ENTRY TO THE ROOST

*E. pumilus* colonies have been found to commence leaving their roosts at dusk and continue to do so in a haphazard manner for about half an hour. There is no indication of a mass exit as a time lapse varying from several seconds to several minutes takes place between the departure of individuals. Chattering and squabbling in the roost is accentuated as the bats prepare to leave, but, if a light is flashed on the exit, activity is depressed and the bats are reluctant to leave until darkness is restored.

Limited observations have not shown that *E. pumilus* has any notable preference for any particular weather conditions. However, on the evening of 13: X: 1962 when light rain was falling, bats began to return to the roost before exit flights had ceased. Of thirteen successful nettings, six were in exit flight and seven in entry flight. Three of the latter had not been taken in exit flight on that evening and appeared to have come from another roost.



When leaving the roost the bats drop from the exit hole to gain momentum and then usually quickly ascend.

Individuals can be seen flying in the vicinity of the roost for a few minutes after leaving but appear soon to move away to more distant places.

Dawn observations of entry flights have shown that the colony may return to roost either in a massed flock or staggered over a period of time.

A year before the study was commenced a massed pre-dawn entry was observed at Green's Beach in February 1961. This roost (designated C) was in a shack roof and entry was gained by the bats dropping into the spouting and crawling along the corrugations beneath the roofing iron to enter a four-inch space between the ceiling and the roof. In the half light of dawn bats were noticed flying in every direction over the roof and garden area of the shack. They appeared so numerous and their flight so irregular that they reminded the observers of a swarm of bees. The number was difficult to estimate but it was thought to be about fifty. The light was not sufficient to follow their flight except when they were silhouetted against the sky and within a few minutes they had completely vanished. Unfortunately circumstances at the time prevented further observations and it was not until sometime later that the roosting site was discovered. It was subsequently abandoned for no apparent reason and has not since been occupied.

Overnight trapping in the "Green's Beach" roost (A) in February 1962 indicated that movement in and out of roosts continued haphazardly throughout the night. In the same month a dawn entry was watched and about a dozen bats were seen to return in the quarter hour before daylight.

At this roost flight terminated in an upward sweep with the bats losing momentum as they reached the vicinity of the entrance in the wall of the shack. If the initial grip on the wall surface was not secure they dropped away to circle and again repeat the attempt. When a satisfactory foothold was obtained the entrance was quickly located and the bat disappeared within the roost. It is, when making these attempted entries, that the bats deposit the faecal pellets which are to be found adhering to vertical surfaces in the vicinity of roost entrances.

*E. pumilus* were found to fly in the vicinity of their roost for only a few minutes after exit and it was most noticeable to the observers that they soon moved further afield.

When disturbed from their roost or liberated in day time they showed no apparent concern at an enforced

diurnal flight. Welcome Swallows *Hirundo neoxena* took interest in their presence and hawked round them as they flew but no other bird or animal appeared disturbed. Some of the bats would return within minutes to re-enter the roosts while others gradually moved away and vanished from sight.

#### IV BANDING

##### (a) Methods.

All the bats collected alive have been secured by three methods:

- (i) Wall panels or similar coverings have been carefully removed and bats collected before they could move away. This method has been used as little as possible because of the greater risk of disturbance.
- (ii) Mist netting has proved successful when the net was strung across the flight lines opposite the entrance to the roost and bats have been taken by this method when leaving or returning to the roosts. *E. pumilus* has been found to become net shy when subjected to repeated netting and will take evasive action if an alternative escape is possible. If nets are well set and completely contain exit routes the bats have been found to mesh well and to be easy to extract if removed soon after netting. In the Kelso roost the bats were captured by laying the mist net over the roof and entrances in a semi-horizontal position to blanket the area and prevent escape. Here the net hung within six inches of the exits and the bats became entangled in the loose netting instead of being properly meshed behind a shelf string.
- (iii) Tin traps have been used with success wherever exit holes were suitable. A standard four gallon kerosene tin with the top cut out makes an ideal trap but any smooth sided container is satisfactory provided the sides are high enough to prevent the bats jumping out when attempting to fly. The trap is suspended immediately below the exit hole in such a position that the bats will drop into it as they start their exit flight. The advantage of this trap is that it can be left unattended and cleared at the convenience of the operator, provided weather conditions are satisfactory or the trap suitably shielded from rain. It was found that the trap had to be removed during the night as otherwise the entry flight of the bats was obstructed and they experienced difficulty in locating the entrance to the roost. Thin plastic bags are not satisfactory for traps or containers as bats will chew holes in the material and escape.

TABLE 1. TOTAL BANDING AND RECAPTURE STATISTICS

Banded Between	Times Recaptured									Total Recaptures
4 : 11 : 1962 - 1 : 1 : 1965	0	1	2	3	4	5	6	7		
♂ ♂ 30	13	11	2	0	2	0	2	0		35
♀ ♀ 93	24	25	11	16	6	6	3	2		181
Total 123	37	36	13	16	8	6	5	2		216

Bands were supplied by C.S.I.R.O. Division of Wildlife Research. Initially these were standard size 020 bird bands and were found to be quite satisfactory. Special bat bands of a slightly different design are now in use. Bands were placed round the radius without piercing the propatagium and were large enough to move freely and not bind on the skin.

#### (b) Results.

Banding was carried out in the Green's Beach, Kelso, and Robigana colonies between 4:II:1962 and 1:I:1965. A total of 123 bats were banded and of these 86 were subsequently recaptured 216 times on 34 trap nights. (See table 1).

With the following exception all recoveries have been at the place of banding. A female banded at Green's Beach on 6:IX:1963 was recaptured at the Kelso roost on 25:IX:1964. The intervening distance is about three miles and the terrain is undulating coastal plain carrying light scrub and stunted eucalypts.

The longest time lapse between banding and recovery is for three females banded at Green's Beach on 4:II:1962. They were recaptured at the place of banding together with eight others on 6:IX:1963, nineteen months after banding. Two had been banded as sub-adults but the third was still showing evidence of recent lactation when banded.

Banding and retrapping has indicated that more than one roost site is used by each colony. The Green's Beach colony used at least two roosts sited in buildings about 12 feet apart and recoveries showed an interchange of occupants: on some days the whole colony occupied one roost, while on others both were occupied.

Netting of banded bats from other colonies has likewise shown the number of occupants to fluctuate daily and individuals present on one evening may be partly replaced by different bats the next, or they may reappear on subsequent occasions. Consequently it was necessary to set nets for several evenings, before all members of a colony were caught and banded. Counts of bats leaving the roost on evenings when netting was not

carried out has shown similar fluctuations.

Two sub-adults removed from a roost site at Green's Beach in the mid-afternoon of 28:II:1965, banded and released, were seen to enter a small hole 4 feet above ground, in a stone chimney about fifty yards distant. Netting at this site on the following evening resulted in the capture of five bats and accumulated faeces indicated that this alternative roost was well used.

#### (c) Seasonal Changes In Colony Structure.

All the roosts examined have produced less than fifty individuals. In those whose occupants were banded numerical strength was at its peak in February following breeding when all the sub-adults were still present, but decreased in the autumn and reached a minimum during the winter months.

In spring the numbers increased until, by the end of October, a full complement of pregnant females was in occupancy.

The spring build-up in the Green's Beach colony in 1962 did not occur till the latter half of October, but in 1963 it started in September. In 1964 the Kelso colony was at its full breeding peak by the end of September but the Robigana colony did not appear in strength till mid-October. There was no apparent reason for these variations but the use of alternative roosts may be responsible.

Of 49 bats captured from the Green's Beach roost (A) in February and March, 1962, 23 adult females were still lactating or had just ceased to lactate. The remainder were 15 females and 11 males, all of which appeared to be sub-adults. Of these 3 adult females, 1 sub-adult female and 1 sub-adult male were killed and processed into the collections. The rest were banded and released.

It is not suggested that the preponderance of sub-adults over adult females indicates twinning but rather a failure at the time to catch all the adult females. Subsequent trapping of this colony in the following spring recovered many of these banded bats and produced the highest number of recaptures from the older females. (See Table 2).

TABLE 2. BANDING AND RECOVERIES AT THE GREEN'S BEACH COLONY

Banded		Recaptured	
Feb.-March 1962		Oct.-Nov. 1962	Nov. 1962 only
As Adult	♀ ♀ 20	19	14
As Adult	♂ ♂ 0	—	—
As sub. Ad.	♀ ♀ 14	9	6
As sub. Ad.	♂ ♂ 7	4	1
Banded	As Adult ♀ ♀	5	0
Oct.-Nov. 1962	As Adult ♂ ♂	0	—

TABLE 3. BANDING AND RECOVERIES AT THE KELSO COLONY

Banded		Recaptured	
February, 1964		Sept.-Dec. 1964	Dec. 1964 only
As Adult	♀ ♀ 24	17	8
As Adult	♂ ♂ 0	—	—
As sub. Ad.	♀ ♀ 9	2	0
As sub. Ad.	♂ ♂ 9	4	3
Banded	As Adult ♀ ♀	6	3
Sept.-Dec. 1964	As Adult ♂ ♂	6	6



The proportion of males decreased as the breeding season approached and was at its lowest numerical strength in early November. This roost was deserted in mid-November and no further observations could be made.

A somewhat similar fluctuation in population structure was found to occur in the Kelso colony in 1964 with the highest number of recaptures again amongst the older females. (See Table 3). None of the first year females remained to breed in this roost in the 1964-65 season, the last recapture being made on 29: XI: 1964, apparently in non-breeding condition.

Of the 9 first year males banded at Kelso 3 remained in the colony over the following breeding season but it was found that from the commencement of parturition in late November, to the end of December, 6 new unbanded males joined the colony. Previous trapping has failed to find any adult males in colonies after January.

The portion of the colony collected at Sheffield on 18: XI: 1964 produced 17 pregnant females, all with embryos at an advanced stage of development, and 7 males.

A somewhat similar sex ratio was found to occur in a maternal colony of *Chalinolobus gouldi* near Melbourne in December, 1961, at which time the colony contained both lactating and heavily pregnant females. (Simpson 1961).

The portion of the colony collected at Lilydale in April 1964 produced 11 females and 3 males, the latter being almost certainly sub-adult.

Trapping at Robigana roost in November and December, 1964, produced 18 females and 6 males.

No explanation can be offered to account for the disappearance of bats from the roost over the winter months. However, winter occupancy by some bats at least and an extended period of use by a high summer population seem to indicate that the roosts in question are not just temporary breeding sites.

One case of species association was recorded when a single *Chalinolobus morio* was taken with *E. pumilus* in a mist net set at the entrance to a roost at Green's Beach in April, 1963. Although it cannot be stated positively that this bat was roosting in association with *E. pumilus*, the limited roosting space available and its suitability make this a strong possibility.

## V. OBSERVATIONS ON BREEDING, GROWTH & DEVELOPMENT

### (a) Breeding.

From the observations made on seasonal changes in colony structure it appears that there is an influx of additional males into a roost immediately prior to and during the period of parturition, but that these males abandoned the colony before the juveniles take flight. It therefore seems reasonable to suggest that this influx is for the purpose of copulation, which may occur soon after parturition, with seminal storage taking place in the females. Post-partum copulation was observed in a colony of *Myotis lucifugus* in Chicago, U.S.A., by Dubkin (1952) and observations on seminal storage in vesperilionid bats in the eastern United States of America have been summarized by Wimsatt (1945).

The supposition that this is the pattern in *E. pumilus* is further supported by a pronounced seasonal variation in the size of the testes in the male. The testes of 5 males taken between the end of January and the end

of October ranged between  $2 \times 1$  mm. and  $1 \times 1$  mm., while the testes of 9 males taken from three different colonies during November ranged between  $4 \times 2$  mm. and  $2.5 \times 1.5$  mm. Enlargement in terms of testes volume is, of course, much greater. Thus the testes are of maximum size and therefore presumably at a peak of spermatogenesis at the time the young are born.

Embryos of 3 to 5 mm. total length were noted in dissected bats collected in the last week of October and abdominal distension was obvious by mid November. During advanced pregnancy the skin of the abdomen became stretched to such a degree that a patch of skin free of fur, about  $7 \times 3$  mm., appeared immediately above the vagina.

Observations and dissection of pregnant bats indicates that breech birth may be customary. The body of the unborn foetus is considerably broader than the head and upon its expulsion the female relaxes and allows the young to withdraw its head by its own efforts. The tail and the uropatagium of the female are held in the position of a "safety net" to support the new born young. Observations of *M. lucifugus* (Wimsatt, 1945) have shown a nearly similar parturition procedure.

A breech birth in which contractions ceased after expulsion of the foetus, and in which the new born young removed its head from the vagina unaided, was noted by the author in the case of the second of twins of *Nyctophilus geoffroyi*, born 20: XI: 1964 (unpublished data).

The young of *E. pumilus* were produced over a period of about three weeks, between the end of November and mid-December. All the material so far examined has indicated that only a single young is produced annually, although McKean and Hall (1964) quoting Dwyer (personal communications) recorded twinning in this species in the New England district of New South Wales.

At none of the colonies visited was a young bat ever found attached to an adult. The 5 juveniles taken from the Kelso roost were all found unassociated and no adult netted in exit flight was ever found to be carrying young. A juvenile bat placed on the breast of a lactating female would quickly attach to a nipple but the adult often became annoyed and removed the juvenile by pulling it away with her teeth.

Although the thumbs and hind feet are used by the young to retain its hold of the parent, they appear of secondary importance to the mouth. In captivity, young bats were often noted to lose their "foothold" and swing attached by the mouth only. They fasten tenaciously to the nipple and some effort is required to remove them. The nipples of lactating females are about 2 mm. long and are surrounded by a 3 to 4 mm. radius of bare skin. In lactating females netted at dusk, this mammary patch was pink, but in those collected from the roost on the mornings of 2: I: 1965 and 8: I: 1965, the subcutaneous glands were distended and appeared a milk-white colour. In the evenings lactating females were found to emerge from the roosts over a more extended period than at other times of the year, though this may have been due to net shyness after repeated netting.

Two pregnant females were collected and removed from the Green's Beach colony in November 1963 and twelve from the Kelso, Robigana and Sheffield colonies in November 1964 in an endeavour to observe birth in captivity. They were held in small cages of about five cubic feet capacity, supplied with water and fed on live house flies and small moths. Most individuals died after 3 to 5 days, only 2 surviving to give birth to their young



and in both instances these were stillborn. One was found dead on the floor of the cage on 16 : XII : 1964. It weighed 0.83 gm. and had a total length of 34 mm. (See Table 4). It was naked with the eyelids closed. Skin colour was primarily flesh pink with the eyelids, nose, lips, ears, fore and hind limbs, tail and patagium grey. A few mystacial and supraorbital vibrissae were present. Milk teeth had begun to erupt, with those on the upper jaw being most advanced. The pes and thumb were noticeably well developed in relation to the other features, the fingers appearing under-developed by the same comparison. General appearance gave the impression that this bat was not a full term foetus.

The birth of the other stillborn bat, on 26 : XI : 1964, was observed by Mr. J. W. Swift of the Museum staff who recorded the following details :

At 0955 hrs. the female was noticed clinging to the wire front of the cage in a head upward position. Her tail was curled upward ventrally to form a pocket and the rump of the young bat could be seen protruding from the vagina. The female's body was heaving irregularly and the young was gradually expelled as far as its head, its body being contained within the curl of the tail. The female rested in this position until 1030 hrs. when she was removed for examination and the young found to have been born dead. The head of the young was easily withdrawn from the vagina and the umbilical cord was cut.

By 1130 hrs. a placenta approximately 5 mm. x 3 mm. had been completely expelled but the bat was of a lethargic disposition and made no attempt at toilet. The female's weight after parturition was 3.84 gm.

The stillborn young, Reg. No. 1964 : 1 : 304 ♂, weight 1.11 gm., total length 38 mm. appeared in fresh condition and was apparently near to a full term foetus. (See Table 4). The body colour was a pinkish grey, darkest dorsally. The fore and hind limbs, ears and lips were a dark grey and the patagium when folded appeared a similar colour but when spread was a transparent grey. The nasal glands were prominent and paler than the surrounding skin. The eyes were closed and the claws sharp and stout.

It was born apparently naked but under microscopic examination short hairs were visible in the region of the nose, on the toes and thumbs particularly near the base of the claws, on wrists, forearm and darkest parts of the ears. Mystacial, supraorbital and interramal vibrissae were present and slightly longer than adjacent pelage hairs.

The canine and incisor milk teeth had erupted, those on the upper jaw being most prominent. Cheek teeth were still contained within a swollen jelly-like gum.

#### (b) Growth and Development.

Five juvenile bats were collected from the Kelso colony in early January 1965 from which the following successive stages of development were recorded. (See also Table 4).

(i) Reg. No. 1965 : 1 : 2 ♀, collected at 10.30 a.m. on 2 : I : 1965, weight 1.35 gm., total length 42 mm. Right eye was open, left eye still closed. Skin colour a grey flesh dorsally, pinkish ventrally. Nose, lips, eyelids, ear tips, toes and distal parts of the patagium, dark grey. The stretched patagium a paler transparent grey. Nose glands almost milk white. Body naked with only a few short microscopic hairs round the nose on the chin, ears, lips, and under tail. A few vibrissae were visible. The finger bones were soft and flexible.

Both upper and lower canines and the milk incisors

had fully erupted and two milk premolars in each lower jaw had just broken through the skin. All other cheek teeth were still contained within the gums.

The upper incisors were slender and well spaced, each with three cusps, the middle cusp being the longest. Three pairs of lower incisors had just cut the gum surface and their form was not clearly visible. The upper canines were strong and well developed. The lower canines were short, stout and had three cusps. The two cusps of equal proportions were formed on the anterior part of the tooth while the third cusp, much shorter and less prominent, was situated posteriorly. All teeth, particularly the upper incisors and lower canines, were strongly curved inwardly and posteriorly giving the impression of claws or hooks, an adaptation which no doubt assists the young bats to maintain their hold on the nipples and fur of the parent.

This bat was very active and continually sought seclusion. It hung head down when at rest in the manner of adults and was an efficient climber. On dissection the stomach was found to be empty but the intestines carried a bright orange fluid through which was dispersed a small amount of fur, apparently from the body of the parent.

(ii) Reg. No. 1965 : 1 : 6 ♀, collected at 11.30 a.m. on 8 : I : 1965, weighed 1.86 gm., total length 47 mm. Both eyes open. Skin colour grey dorsally, pinkish grey ventrally. Nose, lips, ear tips, fore and hind limbs and patagium noticeably darker than the rest of the body.

Body fur emerging and just visible to the naked eye on the dorsal surface where it was about 0.5 mm. long. Hairs on the chin and lips noticeably longer than those on the rest of the head and body. Vibrissae becoming prominent, with supraorbitals reaching to 2 mm. Body fur emerging on the ventral surface but not yet visible to the naked eye.

Teeth slightly more developed than in the preceding specimen, the 3 pairs of lower incisors being well spaced, each with three prominent incurved cusps. One upper and two lower milk premolars erupted on each side, one of the latter possessing a small anterior cusp. (Fig. 2a).

The bat was active and continually sought seclusion. Its intestines contained orange fluid.

(iii) Reg. No. 1965 : 1 : 3 ♂, collected at 10.30 a.m. on 2 : I : 1964, weighed 2.92 gm., total length 55 mm. Head and body covered with dense soft grey fur 2 to 3 mm. in length, shortest and palest on the ventral surface. Dorsal fur extends sparsely onto the anterior half of the uropatagium. Hairs on lips and around the nose, well developed. Vibrissae prominent with supraorbitals longest and reaching to 3 mm. Naked skin on fore and hind limbs, tail, nose, ears and patagium almost completely black. Finger bones soft and somewhat flexible; finger joints not prominent.

The three pairs of lower milk incisors had been lost and were being replaced by permanent teeth, the centre pair being well through the gum. These were stout and broad without inter-spaces; the three incurved cusps being represented in the permanent teeth by a three crescent shaped cutting edge. All other milk teeth still in place. The one pair of upper and two pairs of lower milk premolars well through and appearing as very small needle-like structures. Their setting was irregular and they appeared to be rudimentary. Gums distended by molar teeth which were just erupting (Fig. 2b).

This bat was very active and would hang from objects and initiate pre-flight movements. However,



Plate 1. (Top). Site of the diurnal roost at Kelso. The bats were living behind the fascia board and entering by way of the corrugations on the lower roof.  
(Bottom). Adult female *E. pumilus* and suckling juvenile at about 7 days.









Plate 2. (Top). Adult female *E. pumilus* showing band on left radius.  
 Juvenile (1965 : 1 : 7) at about 45 days.  
 Juvenile (1965 : 1 : 6) at about 18 days.  
 (Bottom). Stillborn *E. pumilus* (1964 : 1 : 304). Almost a full term foetus.







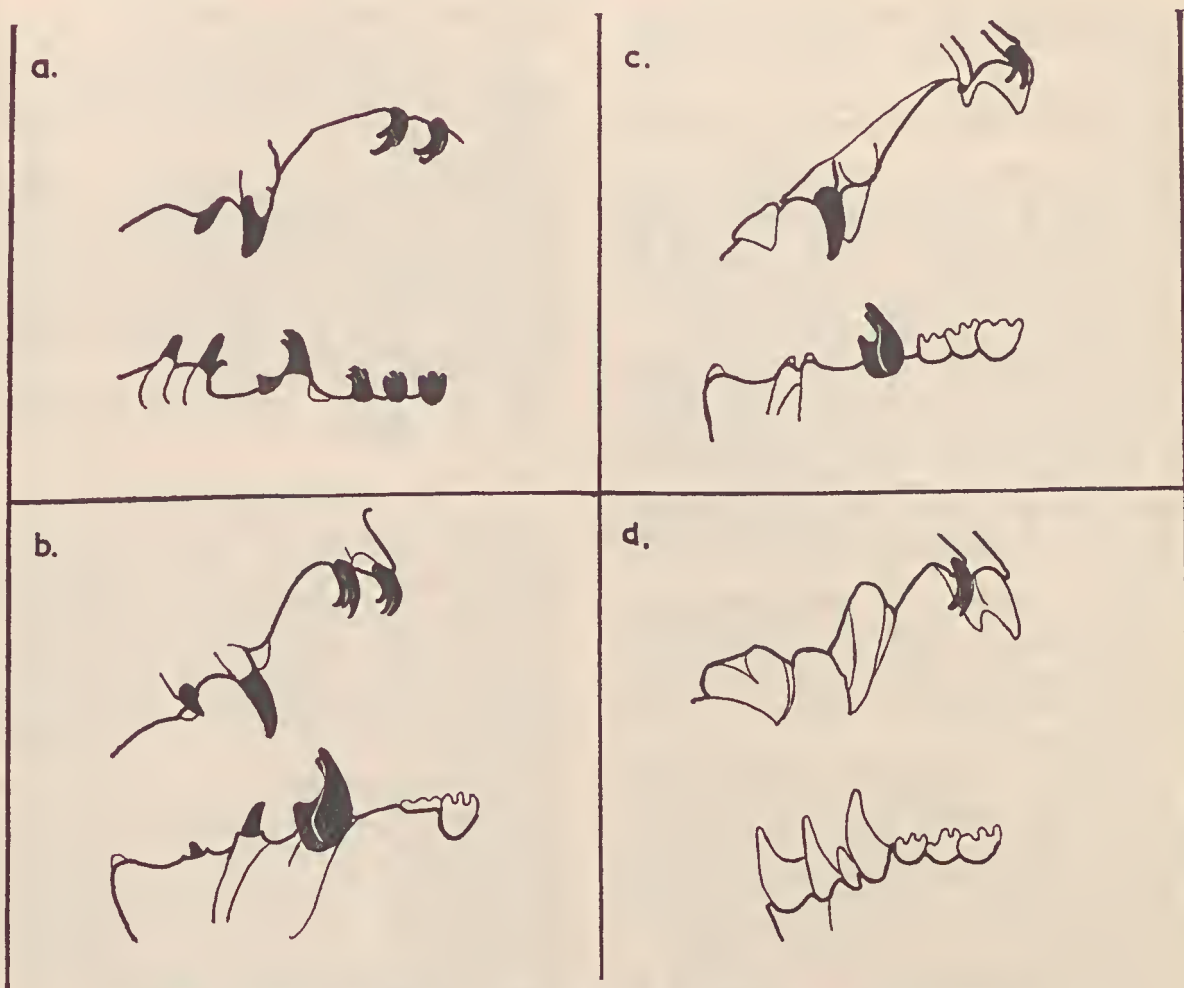


FIGURE 2. Showing the progressive replacement of the deciduous milk teeth (black) by the permanent teeth (white) in right side jaws of *E. pumilus*.

- (a) Reg. No. 1965 : 1 : 6 at about 18 days.
- (b) Reg. No. 1965 : 1 : 3 at about 32 days.
- (c) Reg. No. 1965 : 1 : 8 at about 39 days.
- (d) Reg. No. 1965 : 1 : 7 at about 45 days.

it made no voluntary attempts at flight and when dropped its actions were feeble and completely ineffective. On several occasions the bat was seen to clean its fingers and prepatagium, using its lips and teeth for the purpose.

The stomach contained some curdled milk and small clusters of fur and the intestines contained orange fluid.

(iv) Reg. No. 1965 : 1 : 8 ♀, collected at 11.30 a.m. on 8 : I : 1965, weighed 3.2 gm., total length 61 mm.

Fur colour dark grey to 3.5 mm. dorsally, slightly shorter and paler ventrally. Fur extending sparsely on to anterior dorsal half of the uropatagium. Supra-orbital vibrissae to 4.5 mm. General appearance more adult than the preceding specimen, the fingers being much better developed and the finger joints becoming noticeably prominent.

The two pairs of upper milk incisors were still in place but were being pushed out by the eruption of the central pair of permanent bicuspid incisors. These were very much stouter and stronger, each cusp erupting behind a milk tooth and the new tooth occupying the space of its former two counterparts. The three pairs of permanent lower incisors now completely erupted and occupying all the space available. The upper milk canines still in place but being replaced by permanent teeth which had erupted anteriorly. The lower milk canines still in place and firmly attached; the permanent canines evident only as lumps in the gum on the inner side of the milk canines. Both upper and lower milk premolars absent and replaced in the upper jaw by one pair and in the lower jaw by two pairs of permanent premolars, the single cusps of which had just erupted. All molars had erupted with the cusps just clear of the gums (Fig. 2c).

This bat was very active and would bite at the hand in its endeavour to escape. It made several attempts to fly but its actions were too feeble for it to become airborne.

The stomach contained some curdled milk and the intestines orange fluid with some greyish dirt-like particles.

(v) Reg. No. 1965 : 1 : 7 ♀, collected at 1130 a.m. on 8 : I : 1965, weighed 3.6 gm., total length 67 mm. Fur colour grey, to 5 mm. on the dorsal surface, slightly shorter and paler ventrally, anterior dorsal half of uropatagium sparsely furred. Supraorbital vibrissae to 5.5 mm., mystical vibrissae to 4 mm. Except for size, the bat was superficially adult in general appearance, but with fingers stout and finger joints prominent.

One pair of upper milk incisors still present but loose and pushed well forward by the permanent incisors which were well advanced and extended beyond the tops of the milk incisors they were replacing. The lower milk canines had been replaced by well advanced permanent teeth. All cheek teeth well advanced, with the body of the teeth emerging above gum level (Fig. 2d.).

This bat was very active and made numerous attempts to fly. None of these were successful but it was obviously very near to achieving flight and becoming independent.

The stomach contained a little curdled milk and the intestines orange fluid with greyish dirt-like particles.

An examination of the skulls of juvenile bats taken from the same Kelso colony on 23 : I : 1964 and 5 : II : 1964 (total length 68 mm. and 73 mm. respectively) showed both carried a complete set of fully erupted permanent teeth.

The removal of the facia board covering the Kelso roost resulted in roost abandonment in January 1965. At this time the young bats would not have been sufficiently developed to fly, though some would have been semi-furred and weighed in excess of 3 gm. Their removal from the roost must therefore have been effected by the parent females. A similar case of roost abandonment with removal of the young was noted by the author in the case of a colony of *Nyctophilus geoffroyi* at Green's Beach at the end of November, 1964.

The young become independent of their parent at about 60 days, usually during the month of February.

Sub-adults are morphologically similar to adults except that the finger joints are conspicuously enlarged until the bats are about four months of age. Where this criterion fails, pelage colour and complete absence of tooth wear usually distinguish the sub-adults.

The enlargement of the finger joints does not become noticeable until the young bats develop to the flying stage and it has been found to be prominent in sub-adults collected in March.

The phalanges of pre-flight juveniles appear relatively thick and soft but as the bats develop and become able to fly these bones harden and become more slender. The extremities and finger joints appear to be the last parts to contract and at this stage the joints appear swollen. By September they have become reduced to their normal adult size.

The hind foot is remarkably well developed before birth, (see Table 4) and little or no variation occurs in the length of the pes after the foetus nears full term. Though the foot appears of secondary importance to the mouth in enabling the juvenile to retain its grip on the fur of the parent, it is vital to its safety within the roost. Observations have shown that juveniles move freely about the roost soon after birth and have

been found to hang up by themselves in the same manner as adults, supported by the claws of the pes.

The eruption of vibrissae precedes that of the pelage hairs by several weeks. Embryo Reg. No. 1964 : 1 : 274 (Table 4) was found to have mystical and supraorbital vibrissae just above the skin but the interramal vibrissae were not visible.

Young *E. pumilus* do not usually reach a weight of 4 gm. in the first six months of their life and there appears to be little difference between the sexes at this age. After six months the body weight of females usually exceeds that of males. The heaviest males taken were those collected from colonies during the breeding season when they were found to have enlarged testes. The greatest weight of a male was 4.9 gm. Females reach their greatest weight during advanced pregnancy, the heaviest recorded being 5.8 gm.

The heaviest female taken outside the breeding season was collected on 17 : VI : 1964 and weighed 5.1 gm. (See Table 4).

## VI. PELAGE AND AGE

Pelage colour and texture vary greatly in both males and females. It is in no way indicative of sex but does appear to be influenced by age and possibly by local environment. The fur grows to a length of about 7 mm., the sub-fur being considerably darker than the outer. The ventral surface is always paler than the dorsal.

Sub-adults of both sexes have a soft grey pelage which changes by varying degrees to dark grey and brown as the bats age. The fur of several aged females with extensive tooth wear had taken on a rusty or sandy-brown colour.

Tooth wear is very noticeable as the bats age and this wear is most easily recognised in the incisors, canines and premolars of the upper jaw. By the end of the first year the cusps on the larger incisors are rounded and blunt and the canines and premolars also show signs of wear. This has been observed in banded bats of known age. (See Fig. 3b). In older individuals wear subsequently removes the incisor cusps entirely and the tooth takes on a flat tip, the canines shorten and the premolars are reduced by heavy scalloping of the posterior edge (Fig. 3c, d and e).

Towards the end of life the teeth are reduced to stumps and in one instance an old female was found to have the upper premolars worn through in the middle leaving two independent stumps in place of each of the double rooted teeth (Fig. 3f).

Although there appears to be a correlation between pelage colour and tooth wear there have been some remarkable exceptions to the general rule. One male taken at Winnaleah in north-eastern Tasmania on 28 : II : 1962 was a deep chocolate colour though its teeth were unworn. Only one male has been found with considerable tooth wear and it still retained its sub-adult grey pelage and weighed only 4 gm.

Deep chocolate pelage was unusual in the bats of Green's Beach and Kelso colonies, the colour of adults usually being grey-brown, or rusty brown. However, all bats of both sexes taken from the Sheffield colony, with tooth wear ranging from slight to medium, had deep chocolate pelage. When a series of skins from these areas were placed side by side the locality variation was conspicuous. Both Winnaleah and Sheffield are inland areas — whereas — Green's Beach and Kelso are coastal. Sufficient suitable study skins are not available at present to define the full range of geographical variation.



TABLE 4. PROGRESSIVE MENSURATION GAIN IN *E. PUMILUS*. EXPANDED DIGITAL MEASUREMENTS ARE INDIVIDUAL PHALANGES: PROXIMAL, FIRST, DISTAL, LAST.

Date	Reg. No.	Sex	Approx. Age	Weight (gm.)	Total Length	Tail	Head	Ear	Tragus	Radius	1	3	Digit	Pes	Remarks
18.XI. 64	1964.1.274	♂	—18 days	0.51	26	8	8.5	4	2	7.5	1.5	8.5	4	5	Living embryo
16.XII. 64	1964.1.323	♂	— 7 days	0.83	34	10	10	5	2	9.5	2	10	8	8	Stillborn
29.XI. 64	1964.1.302	♂	— 6 days	0.93	35	11	11	5.5	2	11	3	14	13	10	Living embryo
26.XI. 64	1964.1.304	♂	— 1 day	1.11	38	11	11	5.5	2.5	11.5	3	14	11	11	Stillborn
2. I. 65	1965.1.2	♀	7 days	1.35	42	13	11	6.5	3	13.5	3	14	11	11	Skin naked
8. I. 65	1965.1.6	♀	18 days	1.86	47	15	11.5	7	3.5	17	3.5	17	13	15	Body fur emerging
2. I. 65	1965.1.3	♂	32 days	2.92	55	19	12	7	4.5	22	4.5	25	21	20	Body fur to 3 mm.
8. I. 65	1965.1.8	♀	39 days	3.2	61	24	13	9	4.5	25.5	4.5	35	30	28	Body fur to 3.5 mm.
8. I. 65	1965.1.7	♀	45 days	3.6	67	28	13.5	9.5	5	28	4	20.9.5.5	20. 8.6	21.7.3	Almost flying fur to 5 mm.
5.II. 64	1964.1.17	♀	60 days	3.38	71	30	13	12	6	30	4	24.9.7.7	24. 9.7	24.7.4	Just flying
4.IX. 64	1964.1.244	♀	9 mths.	3.65	76	33	13.5	12	5	30.5	4.5	26.11.9.6	26.10.7	26.8.5	6
18.XI. 64	1964.1.287	♂	1 year+	4.1	71	30	13.5	12	5.5	29	4	25.10.7.7	25.10.8	25.8.5	6 Testes 3 x 2 mm.
18.XI. 64	1964.1.288	♀	1 year+	4.77	75	32	14	12.5	5.5	29.5	4	25.11.9.6	26.10.9	26.8.6	6 Pregnant
17.VI. 64	1964.1.93	♀	1 year+	5.1	78	33	14	11	5.5	31	4	26.12.9.7	26.11.9	27.8.5	6 Heavy tooth wear
18.XI. 64	1964.1.270	♀	1 year+	5.38	80	35	15	13	5	31	4	26.12.8.7	27.11.9	28.9.4	6 Heavily pregnant

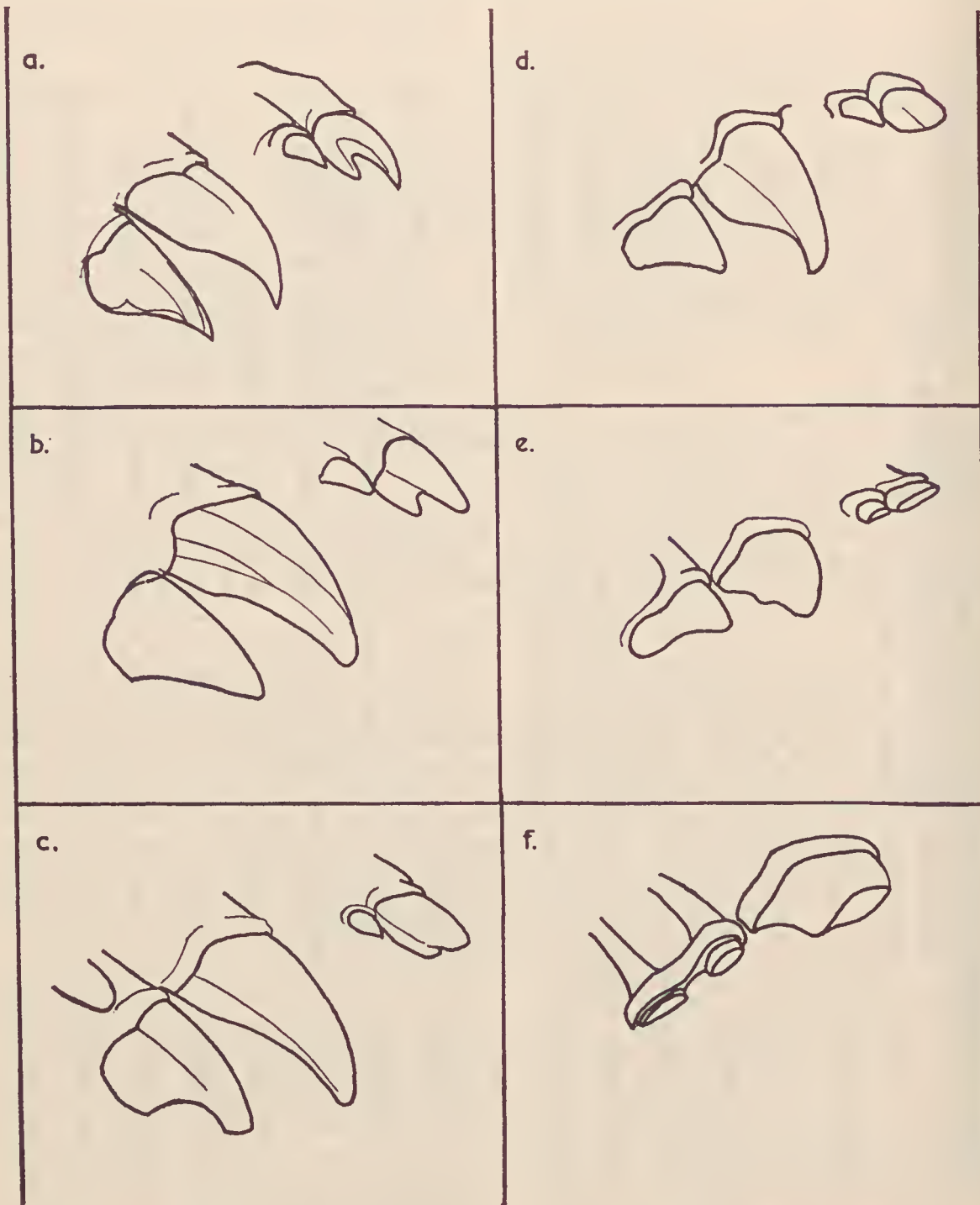


FIGURE 3. Showing progressive wear in the right upper incisors, canine and premolar of *E. pumilus*.

(a) At 3 months old when the teeth have just fully erupted.

(b) At 11 months.

(c, d, e and f). Progressive tooth wear at an unknown age.



## VII. FOOD AND WATER

Observations on free-flying *E. pumilus* have been limited but indicate that they do not ascend much above the tree-tops. Most activity seems to be concentrated below the leaf-canopy and the bats evidently feed on insects which fly about the less dense vegetation. On one occasion a bat was seen to hover five feet above the ground beside a eucalypt sucker as if in pursuit of an insect. It appeared to be hesitant about entering the dense foliage and hovered for 5 to 10 seconds beside the outermost leaves as if trying to locate its prey. Similar behaviour by *Eptesicus scroetus* in England was noted by the Earl of Cranbrook (1964).

There is no evidence to suggest that *E. pumilus* obtains food from the surface of the ground and there does not appear to be any preference for pond, river or lagoon areas when they are hunting.

A captive *E. pumilus* which was liberated in a large room at night to exercise, was often noticed taking small moths attracted by the electric light. These were seized in mid-air, the bodies devoured and the wings discarded in a few seconds, without any apparent alteration in the bat's mode of flight.

An *E. pumilus* which showed no signs of pregnancy was successfully kept in captivity for several months on a diet of live flies and moths. Mince meat or dead food of any kind was always refused. If live insects were placed in the cage while the bat was sleeping in a semi-torpid state, the activity of the insects appeared to slowly stir the bat and within five to ten minutes it would be actively pursuing the insects about the cage. Smaller insects were seized in the mouth and quickly devoured, but large flies and moths or anything difficult to handle was seized in the mouth and forced onto the bat's belly and held in a pocket formed by the animal sitting on the lower part of its back with the tail forward and with the uropatagium and patagium forming a pocket. Here the insect was easily handled and devoured at leisure. Only the more succulent body parts were eaten, the wings and legs being rejected.

Even in confined spaces sight appears to play very little part in the bat's location of an insect as on many occasions it was seen to grope for a fly only an inch from its face as if uncertain as to where it was. While the insects remained still, the bat was less inclined to take them, but when active the bat hunted more determinedly.

Water did not appear to be taken in any quantity by captive animals. It was never seen to be acceptable in a saucer-shaped container but when spilt the animals would sometimes lick it from the floor. Bats often became wet as they accidentally blundered over a small container of water and would later be found cleaning themselves and licking the moisture from their fur. These habits suggest that in the wild state they do not drink as most other mammals do, but lick surface moisture from foliage, etc. and no doubt assimilate a limited amount when cleaning their fur following nocturnal flights on wet nights.

In the autumn of 1964, the moth *Dasypodia selenophora*, Guen., was not uncommon in the Green's Beach area. It is a handsome brown insect with a wing span of up to three inches and is often found inside houses. On a number of occasions it was found inside the paling hut in which the Green's Beach roost (B) was located. Wings of this moth were also found scattered about the floor and on one day 16 individual forewings were

collected. Evening observations consequently revealed that *E. pumilus* often entered the hut when in exit from its roost in the roof and spent some time flying round inside before departing by way of a space between the roof and walls. Though the bats were not observed feeding on these moths it seems possible that they were as no other insectivores were known to enter the building. However the possibility of the predator being a bat species larger than *E. pumilus* cannot be disregarded.

## VIII. MISCELLANEOUS OBSERVATIONS

*E. pumilus* is noisy when active in the roost and utters a sharp "chzit" rapidly repeated. It is used in anger when an active bat is restrained and the bat continues uttering the sound while biting. Similar utterances can be heard coming from within roosts in hot weather and when the bats are squabbling at the exit holes prior to their evening flight.

They sleep head downward, sometimes individually, sometimes clustered together to form a mass and even clinging to each other. To urinate and defaecate they turn head upwards, but do not move away from their resting place. Only a few drops of urine are passed at a time and the bat soon returns to its original position. The whole process takes one or two minutes. Neighbouring bats in the cluster do not appear to be soiled by this habit.

Toilet of the fur is usually carried out during the settling period following flight or disturbance. The forelimbs, patagium and tail are cleaned with the lips and tongue, the fur is licked and often scratched with the feet, following which the nails are cleaned with the teeth.

Flight is initiated with ease from a horizontal plane by an upward jump which carries the bat clear of the surface before the wings are brought into use.

When placed on water *E. pumilus* was found to be able to swim vigorously. The wings are semi-extended and beaten in a series of rapid short jerks just beneath the surface of the water. The tail and uropatagium are held fully outstretched and the head held high. The sub-fur does not wet easily but the bat is unable to take off from the surface of the water. It swims to nearest object and climbs free without difficulty. Wet fur is licked and the bat flies when only partly dry.

*N. geoffroyi* has been observed to swim in a somewhat similar manner. (McKean and Hall 1964).

Ectoparasites have been collected from *E. pumilus* and lodged with the National Insect Collection, C.S.I.R.O., Canberra. Mites and louse-flies were found to be plentiful, particularly during the breeding season and a few small fleas were also present.

Ectoparasites were not found on the naked juveniles but they became established once the fur of the host reached about 2 mm. in length.

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## REFERENCES

- Earl of Cranbrook, 1964: Transactions of the Suffolk Naturalists Society, 12 Part 5. (January 1964). Reviewed in Nature, Vol. 202, p. 862.
- Dubkin, Leonard, 1952: "The White Lady". Published in U.K. by MacMillan & Co., 1952.
- McKean, John L. and Hall, L. S., 1964: Notes on Microchiropteran Bats. The Victorian Naturalist. Vol. 81 (2), pp. 36-37.
- Simpson, K. G., 1961: A Rooftop Breeding Colony of Gould's Wattled Bat. The Victorian Naturalist. Vol. 78 (11), pp. 325-327.
- Wimsatt, William A., 1945: Notes on Breeding Behaviour, Pregnancy, and Parturition in some Vespertilionid Bats of the Eastern United States. Jour. Mamm. Vol. 26, No. 1, pp. 23-33.

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